eighteen. The latter are understood to have justified their selection, and in the opinion of some officers were superior to the Dartmouth entry in certain respects. One reason for such a superiority, if it really exists, is so dominant that it is unnecessary to look further. The "direct entry" midshipmen finished their education uninterruptedly at the schools, carrying it on to the age of seventeen and a half or eighteen. The Dartmouth boys were sent to sea prematurely, many of them at fifteen and a half instead of at the normal age of seventeen. They were an unfinished product, and from an educational point of view it is satisfactory that this curtailment of general education should have had such a marked effect on efficiency at sea that many officers were led to make the comparison referred to above. For the reason stated, the comparison could not be fair, but it was made, and it set naval officers thinking.

Not so many years ago it was axiomatic in the Navy that sailors "must be caught young," at a tender age, and not when they leave a public school. It is no longer axiomatic. There is acute division of opinion among naval officers on this subject. So long as it was considered necessary that cadets of thirteen and upwards should spend one-quarter of their time in engineering, it was impossible to look to the schools of the country for the secondary education of naval officers. But the amount of engineering to be learnt in future between thirteen and eighteen is not more than could be taught at any well-equipped school. The problem is therefore open whether the Navy is to continue to undertake the secondary education of its officers, or to leave the task to the schools. The First Lord stated that the Admiralty had no intention of abolishing Dartmouth as well as Osborne, and referred to advantages which could be conferred at a naval college on the sons of needy naval officers. But he believed the public-school system of entry—the "direct entry" system—to be thoroughly good, and fifteen midshipmen are to be entered annually from the schools, as against 120 through Dartmouth.

In favour of maintaining a naval college for cadets is urged the advantage of early acquaintance with Navy habits and discipline, the doubt whether the numbers required—very moderate numbers now—could be recruited at the age of eighteen, the present overcrowded state of the public schools, and the special consideration referred to by Mr. Long in his speech. In favour of relying entirely on the schools of the country, many naval officers argue that a boy's outlook is narrowed by association from so early an age with none but those of his own profession; that there is nothing at a naval college which quite makes up for the influence exerted by a good public-school house master; that "direct entry" saves heavy expense to the Exchequer; and that it is more difficult to select at the age of thirteen than at eighteen.

The debate, therefore, has begun, and the outcome will probably be determined by the eventual balance of opinion within the Service.

The Ultimate Data of Physics.

An Enquiry concerning the Principles of Natural Knowledge. By Prof. A. N. Whitehead. Pp. xii + 200. (Cambridge: At the University Press, 1919.) Price 12*s.* 6*d.* net.

PHYSICISTS and philosophers can unite unreservedly in an expression of gratitude to the author of this most acute and original work. At the present time, when it is generally recognised that the ultimate concepts of physics require reinterpretation, it is a piece of great good fortune that the task should be undertaken by a thinker who is not only one of the foremost of living mathematicians, but also a metaphysician who sees clearly the wider issues that are involved.

As Prof. Whitehead remarks, the incoherent character of the traditional concepts of speculative physics has long been a commonplace in philosophical treatments of the subject. Instantaneous moments, geometrical points, unextended particles, etc.—these may be convenient, and even essential, notions for the purposes of physical investigation, but, if taken to indicate existent entities, are quite unworkable notions. On such a basis the fact, for example, of change in all its forms would become not merely incomprehensible, but contradictory; to be intelligible, "change must," as Lotze put it, "find its way into the inside of being." In other words, change as mere sequence, as mere alternation, is an impossible thought. Change means, if it means anything, continuous modification in that which preserves a certain identity or unity, without, however, implying that the latter ingredient is something separate from the former. Nothing which is characteristic of force, velocity, energy, and life can exhibit itself at a durationless instant. The slightest functioning of a living organism obviously takes time, but so also does that of a molecule of iron. In Aristotelian language, it may be asserted that the true nature of any real existent is never that which can be present all at once, but that which is being realised in the totality of phases through which the existent thing in question passes.

Since the appearance of his well-known paper in the *Phil. Trans.* of 1906, Prof. Whitehead has been wrestling with the problem which considerations such as these occasion, and he has now worked out a positive theory of the structure and diversification of Nature, upon the basis of which a rationale can be furnished of the concepts indispensable in mathematical physics. The aim, then, of the present volume may be said to be twofold: (1) To determine by analysis of what is offered in perceptual experience the ultimate data of science and their relations; and (2) to show how the concepts of mathematical physics and their relations can be exhibited as functions of the former.

Nature, so I understand Prof. Whitehead to mean, must be regarded as in its totality a continuous stream of process, of becoming, of creative advance. Within this whole there call to be distinguished two essentially different, yet intimately connected, types of entity—events and objects. Employing, again, Aristotelian phraseology (and in many ways Prof. Whitehead's scheme of Nature more nearly resembles the Aristotelian scheme than any other), events constitute the ὕλη and objects the εἶδος of things. Events are either durations or bits of a duration, and a "duration" is a "slab of Nature," limited temporally, but unlimited spatially, which is contemporaneous with the specious present of any percipient. The fundamental relation of events is that of extending over each other, and this relation of "extending over" is the common root from which both temporal extension and spatial extension take their origin. Strictly speaking, events themselves do not change; they pass into other events, and in passing become parts of larger events, the passage of events being extension in the making. Moreover, some of the events that are parts of durations (*e.g.* a specific state of perceiving) have a relation of cogredience to a certain duration—that is to say, they are temporally coextensive with it, and they occupy in it a fixed spatial position. Furthermore, events are the "situations" of objects—an object is located in an event as that event's characteristic or quality. Like Aristotle's εἶδος, an object is permanent. When we speak of its change we really mean its diverse relationships to diverse events. Precisely the same object can characterise two or more events. The continuity of Nature is to be found in events. The atomic properties of Nature reside in objects. There is, in short, a structure of events (an "ether of events" rather than a material ether), and it provides the framework of the externality of Nature within which objects have their subsistence. This structure is capable of being analysed in a number of different ways, and by adopting different modes of analysis we human beings can get at the various kinds of events which are "situations" of different types of objects. The more important of these types are: (*a*) Sense-objects—*e.g.* definite sense-data; (*b*) perceptual objects—*i.e.* the so-called "things" of ordinary experience; and (*c*) scientific objects—*i.e.* the characteristics (electrons, etc.) of events as active conditions. With the exception of those perceptual objects that are delusive, all these types of objects are equally real. Their *esse* is neither *percipi* nor *intellegi.*

For the mathematician the detailed working out of the way in which the concepts of point, instant, particle, etc., may be brought into connection with the data just indicated will probably be the most valuable part of the treatise; but I must be content to record that it is accomplished through persistent applications of what is named the method of extensive abstraction. This method, it is explained, is that which in its own sphere (the sphere, namely, of geometry and mechanics) follows the procedure of the differential calculus in the region of numerical calculation. It converts a process of approximation into an instrument of exact thought. By its means, as Dr. Broad has neatly expressed it, the *convenience* in these concepts is retained, while the *fiction* in them is eliminated.

With the main principles of Prof. Whitehead's philosophy, yielding, as they do, a view of Nature strikingly antithetical to that of the logical atomism developed by Mr. Russell, the present reviewer is in close agreement. One would like to press, indeed, for a fuller elaboration of the notions of "duration," "event," and "passage of events" than is here attempted. For one has an uneasy feeling that a host of embarrassing problems lies concealed in those notions. And then, again, one is uncertain about the mode in which events are supposed to be apprehended. While objects are recognised, events, we are told, are "lived through," by which apparently we are to understand that not only the "percipient event" (*i.e.* the actual phase of experiencing), but also the whole duration with which it is cogredient is "lived through." Yet obviously it is not meant that the countless other events, some cogredient and others not with that duration, are in like manner "lived through," and one fails to see how there can be any unique process of apprehending *them*. Once more, one would be prepared to question whether "sense-objects" are primary as compared with "perceptual objects"—primary, that is, in the sense that the recognition of them is precedent to the recognition of the latter. But the last two of these criticisms turn upon matters of detail, and the first amounts to a large order. When all this is said, the fact remains that in the volume before us we have a really great effort of constructive thinking. Prof. Whitehead modestly observes that his book "raises more difficulties than it professes to settle." He adds, however, with true insight, that "to settle the right sort of difficulties and to raise the right sort of ulterior questions" is to accomplish one step further into Nature's background of mystery.

G. DAWES HICKS.

Life and Letters of Silvanus P. Thompson.

Silvanus Phillips Thompson, D.Sc., LL.D., F.R.S. His Life and Letters. By J. S. and H. G. Thompson. Pp. ix+372. (London: T. Fisher Unwin, Ltd., 1920.) Price 1*l.* 1*s.* net.

IF this biography of the late Silvanus P. Thompson, written by his wife and daughter, is perhaps a little wanting in the detached criticism that could have come only from someone outside the family circle, it gives, from an inside and intimate point of view, a good idea of the extent to which its subject appreciated the gospel of work, and how he applied himself, with all his might, to the many varied and interesting things that he found for his hand to do.

The book commences with some account of Thompson's Quaker ancestry and his early training at Bootham School, York, and at the Quaker Training College at Pontefract. Later, Thompson returned to Bootham School as a junior master, and it was during this time that he made the first of many visits to the Continent, which he evidently greatly enjoyed, and which did so much both to widen his outlook and to increase the large number of his foreign scientific friends. His appointment as lecturer on physics at Bristol was the first step in his scientific career, and at Bristol he remained, lecturing to his students and also, farther afield, to various popular scientific societies, attending meetings of the British Association, and making many contributions to electrical science, until his appointment as principal of the Technical College at Finsbury, which was the chief scene of his labours for the remaining thirty-one years of his life.

Essentially fitted by Nature to be a teacher and an exponent, and endowed with habits of industry to a rare degree, Thompson touched little that he did not to some extent adorn, and while in an age of specialism, by reason, no doubt, of a certain diffuseness of his interests, he never concentrated sufficiently upon any one branch of scientific research for his name to be associated with any first-class discovery, there can be no doubt as to the considerable extent that, by his books, his lectures, and his teaching, he forwarded the progress of science, and especially of its applications, during many years of activity. We learn that with remarkable industry he was the author of no fewer than seventeen published books, besides eleven others that were privately printed, while his addresses and communications to societies during the forty years from 1876 down to the date of his death number 177. Electricity, magnetism, optics, and acoustics were his principal subjects, but he also wrote on educational, religious, and other questions, while not least amongst his writings will be considered his biographies of Kelvin and of Faraday, and his notes on the lives of Peter Peregrinus, the soldier of fortune who penned his treatise on the magnet as early as the thirteenth century; Gilbert, the Elizabethan physician, who also wrote on the magnet; Sturgeon, the inventor of the electro-magnet; and Phillip Reis, whose apparatus, if it was not sufficiently developed to become of practical utility, was, at any rate, the forerunner of that wonderful instrument of sublime simplicity, the speaking telephone of Alexander Graham Bell.

Thompson, too, at an early stage in his career, tried his hand at practical telephonic invention, but his ingenious valve telephone was held by the courts to be an infringement of the Bell-Edison patents, and its sale was prohibited. Only on one other occasion do we find him coming out as an inventor, this time in connection with submarine cables for telephonic and high-speed telegraphic purposes. Here, though his particular arrangement of inductive leaks never came into practical use, it led the way to the Pupin loading coil, with which much has been accomplished.

It is recorded that, as a young man, Thompson cared little for games; but that this did not mean any lack of appreciation of the lighter aspects of life is evidenced by the vein of humour in many of his letters, and by the prominent part he took in connection with the "Red Lion" dinners of the British Association, and with such clubs as the Gilbert Club and the Sette of Odd Volumes, in which latter he bore the appellation of Brother Magnetizer. He also had many hobbies, some of which were not scientific, as, for instance, music, poetry, and painting, while as an artist himself he held no mean place, and occasionally exhibited